REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY *(LEAVE BLANK)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	17 March 1999	Professional Paper

4. TITLE AND SUBTITLE

The Use of Commercial Standards in DoD Applications

5. FUNDING NUMBERS

6. AUTHOR(S)

Sidney Jones, Jr. Tom DeSelms

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Naval Air Warfare Center Aircraft Division
22347 Cedar Point Road, Unit #6
Patuxent River, Maryland 20670-1161

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Naval Air Systems Command
47123 Buse Road, Unit IPT
Patuxent River, Maryland 20670-1547

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT	12b. DISTRIBUTION CODE
Approved for public release; distribution is unlimited.	

13. ABSTRACT *(Maximum 200 words)*

The current DoD policy for Acquisition Reform uses COTS products whenever possible to avoid development costs of new systems acquisition. The Next Generation Instrumentation Bus (NexGenBus) project is currently evaluating commercial standards for a high-speed instrumentation bus standard. Since commercial vendors, institutes, and groups design these standards for commercial applications, DoD cannot blindly adopt one of these standards for use in military environments. The standard should be tested, evaluated, and possibly changed based on the application. Using COTS products to evaluate a commercial standard can be tricky - if a unit fails, which is at fault? From a standards perspective, deviations are never desired, though they are required to make it usable for a specific application (e.g., test instrumentation) and creating a nonconforming variation to the standard.

14. SUBJECT TERMS	15. NUMBER OF PAGES
Commercial-off-the-shelf (COTS) Next Generation instrumentation Bus (NexGenBus)	18
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

The Use of Commercial Standards in DoD Applications

Sidney R. Jones, Jr.
Naval Air Warfare Center, Aircraft Division
Patuxent River, MD

Tom DeSelms
Eagan McAllister Associates, Inc.
Lexington Park, MD

Abstract

The current DoD policy for Acquisition Reform uses Commercial-Off-The-Shelf (COTS) products whenever possible to avoid development costs of new systems acquisition. The Next Generation Instrumentation Bus (NexGenBus) project is currently evaluating commercial standards for a high-speed instrumentation bus standard. Since commercial vendors, institutes, and groups design these standards for commercial applications, DoD cannot blindly adopt one of these standards for use in military environments. The standard should be tested, evaluated, and possibly changed based on the application. Using COTS products to evaluate a commercial standard can be tricky—if a unit fails, which is at fault? From a standards perspective, deviations are never desired, though they are required in some circumstances. There is a fine line between adapting a commercial standard to make it useable for a specific application (e.g. test instrumentation) and creating a non-conforming variation to the standard.

1 Introduction

The increased fusion of data from numerous sources (i.e. analog measurements, digital buses, digital radar data, and digitized video) will overwhelm the traditional approach of adding instrumentation busses whenever more bandwidth is required. A single standard instrumentation bus with data rates at least 10 to 40 times that of current systems is required. To comply with Acquisition Reform and with the emphasis on COTS hardware, the instrumentation community requires a commercial standard for the next generation high-speed instrumentation bus standard.

Today there are no high-speed commercial instrumentation busses on the market therefore choosing an instrumentation standard is not a matter of choosing a commercial bus with the widest installed user base, the most capable system, or the cheapest components. Any commercial bus chosen must be evaluated for use in the test and evaluation environment. The test and evaluation environment includes temperature vibration, timing, topologies, installation, and maintenance issues. The completion of this evaluation results in a profile for use by the instrumentation vendors. In its simplest form, the profile would say "See Standard xyz". More likely the profile will limit the number of allowed options, tighten certain parameters, and change some of the physical attributes.

2 Choosing a Standard

The shift of DoD to COTS products is necessitating a hard look at using these products in more stringent environments. Choosing a COTS product to use requires a thorough knowledge of the application. The same is true in the standards arena. A standard is defined as "something established by authority, custom, or general consent as a model or example". DoD must alter its approach to standards from that of authority to one of consent in order to allow the use of new COTS products. The number of standards available requires a thorough search for the best fit. It would seem that more available standards should provide a better opportunity to find the exact standard required. However, the system designer must consider cost and schedule as well as performance. The best technical fit may not provide the best overall solution. The life cycle cost of implementation is getting more attention for example, when there is community support for a standard the overall costs decrease.

The commercial market is driven by profit. DoD personnel must grasp this to understand the 'why and how' new standards are developed. New standards are proposed to allow multiple vendors to develop interoperable equipment. The companies that provide the best fit to a new standard early in the process (i.e. they wrote the standard) stand to make the most profit. The result is a proliferation of promising, but competing standards. Conversely, once a company has staked out ground in a successful standard, they fight to keep the standard evolving rather than backing a new one. A new or revised standard is written to replace its outdated parent or to broaden the influence of its sibling. There are many standards to choose from in various states of maturity. How should one be chosen?

The task of choosing a standard is not as easy as it first appears. There are many aspects that need to be considered. The relative importance of each will be dependent upon the application and the reviewer. Most likely there will be one or more fundamental performance characteristics. Using these performance characteristics, it is important to narrow the field down as quickly as possible by applying a broad filter. Once the number of candidates is down to

some manageable number, some intangible characteristics need to be evaluated along with the remaining performance issues. The performance issues are specific to each application and will not be discussed. However, there are a few criteria that should be considered along with performance characteristics. These criteria will help balance a purely technical decision with some thought to commercial viability.

In broad terms, the criteria used along with performance characteristics can be stated as follows: standards viability, commercial acceptance, and scope. Once selected for an application, standards must stay in place for years to be effective. As such, it is important to understand the maturity level of the standard. A standard that was written last year may contain the latest bells and whistles, but may lack the maturity needed to resolve each vendors interpretation of the standard, thus allowing devices that followed the standard to still not be fully interoperable. Conversely, a standard that's been in use for many years may have been modified superbly, but because of technology advances may be nearing the end of its useful life. The activity level of particular standards working groups may also temper the maturity aspect of a standard. No activity in a working group could indicate a lack of interest in evolving the standard. If the application is somewhat unique, some minor adjustments to the standard may be required. The safest method to evaluate a standard is to attend the working group meetings sponsored by the standard.

Another aspect of standards evaluation is the return on investment. One of the best ways to evaluate this is to research the market place to see what is being offered for sale. Are multiple vendors or one vendor offering the products? How do prices for similar units using competing standards compare? What articles are being written about these standards in the trade journals? Performing this analysis once will highlight which standards are in use today. Analyzing this analysis over several months will give trend data to assess which standards dominate the market today and which hold the most promise for tomorrow.

After an initial list of standards has been reduced to a manageable few, scope will still be an important consideration. Several of the resulting standards may perform adequately. Understanding the scope of the application and the nuances of the various standards may tip the balance toward one standard or another.

3 Testing a Commercial Standard

The applicability of a standard to an application requires an understanding of the critical characteristics of both the standard and the application. Testing the standard is a matter of ensuring the standard works in the new applications environment and the new application can be handled by the standard. The critical parameters are not necessarily the same for both, however, a percentage probably overlap. It is this complete set of critical parameters that must be addressed in testing. There are three questions that need to be asked – what to test, how to test, and what happens when it doesn't work.

Leading commercial standards will generally have some commercial products available that can be purchased to use as COTS Units Under Test (CUUT). COTS units used to verify a commercial standard begs an interesting question. What is being tested? Most commercial standards approved by one of the national standards organizations have had significant amounts

of testing. Therefore, testing to ensure the standards document is correct doesn't make a lot of sense. Unless the CUUT is ruggedized for use in the military environment, finding its deficiencies doesn't provide any answers as to the standards applicability in this new environment.

Another question that needs to be answered is "How to test". When using a CUUT, development test points are unavailable. Testing individual components is not always an option and testing the unit as a system doesn't provide any insight as to which component failed. Without the knowledge of what failed and why, it's not clear whether the standard wasn't written correctly or the CUUT was at fault. It also isn't clear whether either could be modified to work in this environment.

Finally, there are three options if the tests should fail. For minor problems, the requirement should be reexamined. Can the job still be accomplished if the requirement is relaxed? If it can, this is the preferable approach. If the requirement is hard, the next thing to consider is changing the standard. CAUTION, this shouldn't be done lightly. Indiscriminately modifying the standard may sacrifice everything a commercial standard has to offer. However, sometimes there are good reasons to change a standard. The third option is to try a different standard.

The answer to testing commercial standards using CUUTs is a mix of analysis, lab testing, and simulation. Critical areas that cannot be readily tested should be analyzed. Testing should be used where it is required and in support of simulation. Simulation is used to provide results where testing is too difficult or expensive and to extrapolate the results of analysis and testing to the application environment.

4 The NexGenBus Approach

4.1 Goal

The goal of the NexGenBus Project is to establish a commercial communications bus as a standard for the test instrumentation system of the future.

4.2 Understanding the Requirements

Before evaluating the commercial busses, the system features of a composite future data acquisition system were identified. The composite data acquisition system included elements of data systems existing today along with future elements envisioned by the NexGenBus team. This enabled the NexGenBus team to understand the type of data acquisition system a future instrumentation bus must support. One of the major features of such a system is the ability to bridge to data acquisition units on other busses allowing existing instrumentation inventories to be used. Other features included open system architecture, simultaneous sampling, various data inputs and outputs, smart transducer support, environmental constraints, and network topology.

The composite data acquisition system definition was used as a framework to define the NexGenBus requirements. This method enabled the team to track the NexGenBus requirements to a specific data acquisition element. For each data acquisition element the required bus characteristic was determined. The bus requirements list included quantitative instrumentation

measurements such as vibration and acoustic sampling requirements, digital data (serial and parallel), video (weapons release) and audio requirements. As insights and information were gained on the bus characteristics, the requirements list was updated.

4.3 Bus Standard Selection

A comprehensive search was implemented for non-proprietary communication busses. This search entailed generic open searches on the web using several of the more prominent search engines. This was closely followed by thorough searches of standards organizations (IEEE, ANSI, etc.). Trade journals and technical magazines provided timely information on trends and busses used in the commercial industry. The search turned up more than thirty-three busses.

Some of the larger instrumentation systems in use today have data rates exceeding 50 Mbps through the use of multiple busses and multiplexers. The correlation of time sensitive data across these multiple busses can be tricky at best. To ease this burden, there is a trend of combining numerous sources (video/data/voice) onto one very fast bus. With this in mind, the minimum requirement for bus speed was considered to be an order of magnitude greater than the current 10 Mbps standard. Eight serial busses with rates greater than 100 Mbps were identified. These eight busses were selected for review and grading. The purpose of this stage was to quickly eliminate those busses that could not reasonably be used in an instrumentation environment. An evaluation sheet was generated based on some of the identified critical requirements. The final grading on the eight busses showed three clear leaders, Fibre Channel, FireWire and Gigabit Ethernet

The resultant three busses were studied in more detail. This next phase focused on whether the busses could perform critical instrumentation related tasks such as class of service, latency, and synchronicity. These busses were judged on market as well as performance factors. The down-select criteria for this third cut considered thirteen items within three main areas: viability, commercial acceptance, and technical scope. Fibre Channel was the winner again. This evaluation supports what is being seen in other DoD activities. Of the three busses, ***Fibre Channel is the only one being used in a military flight environment.***

4.4 Testing

The Fibre Channel standard is structured as five functional levels identified as FC-0 through FC-4. These levels are based on the lowest four layers of the seven-layer Open System Interconnect (OSI) model used throughout the communications industry. Testing Fibre Channel within its functional levels provides a solid base for the test program.

The goal of the test program is to identify weaknesses in areas critical to instrumentation. However, because we are testing COTS end-items, we may be unable to isolate the area under test. Therefore we shall test a function over several layers and interpolate the results. The major areas of the test program are lab testing and simulation.

4.4.1 Lab testing

The requirements used in the evaluation portion of the down select were used as the theoretical "best" areas in which to test the Fibre Channel layers. The lab set-up however required a

mapping from the theoretical "best" areas to the actual layer in which the tests were performed. For example, the data rate in Fibre Channel is defined at the FC-0 (physical) layer. The actual testing of the data rate was tested at the FC-4 (application) layer. Whenever possible, ways to work within the standard to avoid these weaknesses were noted and allowed the test team to track the areas of deviation from the standard for possible analysis at a later date. The selected tests were oriented towards operational requirements. Development tests were considered as a secondary objective and oriented toward ensuring the operational requirements. The testing activity will be accomplished in two stages. The first stage is oriented toward port testing and the second stage is oriented toward node testing. Each of these stages is composed of multiple test categories. The objective of the port testing is to establish benchmark tests and to determine if the port functions meet the operational requirements. The exit criterion for this stage is based on the effectiveness of the port functions to meet the operational requirements. The objective of the node testing is to build upon stage one by testing selective protocols. The protocols selected will be the results from the protocol simulations. The entrance criterion for this stage is based on the effectiveness of the protocol simulations for the operational requirements. The exit criterion is based on the node functions meeting the operational requirements.

4.4.2 Simulation

There are areas within a standard which are better left to simulation. These areas include new protocols, loading analysis, flow control, Bit Error Rate (BER) and error correction. Simulating a protocol or introducing errors in a simulation may be much more cost effective than doing actual testing. "Test where you must, Simulate where you can" defines a philosophy whereby the requisite test points are done in the lab but the difficult or impossible test points are done in a simulation. This complements the lab testing and saves the cost of expensive test equipment. However, since a simulation is only as good as the parameters that are input, lab testing is required to provide verification of the simulation.

There are multiple protocols that can be run on top of Fibre Channel. Part of the test program includes simulating a data acquisition network using various protocols on top of Fibre Channel in order to select the best one(s). The simulation results will help to determine what topology and protocols are best suited for the NexGenBus. The requirements that will be modeled are Data Rate, Synchronicity, and Latency. Data will be collected and compared for several protocols. The effect of topology on these criteria will also be investigated. We will simulate a series of file transfers and record the message delay and transfer rates. This will be done for several protocols and classes of service. The results from the lab will be compared to those from the simulations to verify the accuracy of the model. Any discrepancies will be analyzed and the model will be adjusted as necessary to best simulate the actual operation of Fibre Channel. Once the model has been verified it will become our baseline model. Due to the nature of the baseline model, synchronicity will not be measured in the initial simulations.

Once the baseline model is established, we will proceed to experiment with topologies. These topologies will include Arbitrated Loop, Meshed Fabric, and other combinations. Using the modeling approach provides the flexibility to perform "what-if" type scenarios with the bus architecture, such as, what if a link becomes over utilized or goes down altogether.

5 Summary

There is leverage to be gained from using COTS products and standards in DoD applications. New technology can be incorporated much more quickly and cheaply. However, all of the advantages of using a commercial standard in a program can be quickly reduced to zero if used improperly. The requirements of the application and the limitations of the standard must be understood and taken into account.

The Use of Commercial Standards in DoD Applications

Next Generation Instrumentation Bus

Sidney R. Jones, Jr.
Naval Air Warfare Center

Tom DeSelms
Eagan McAllister Associates, Inc

Remove
~~http://NexGenBus.Nawcad.Navy.Mil~~

April 20, 1999

Introduction

- High Speed Instr Bus w/ rates 10-40x current systems is required
- No high speed commercial instr busses available
- Must choose best available commercial standard

Choosing a Standard

- Know your application
- Search for the best overall fit
  - Cost, Schedule, and Performance
- Understand 'Standards Dynamics'
  - Companies participate to help the bottom line
  - Companies don't easily switch -- even for better technical capability

Choosing a Standard (cont)

- Use major tech criteria to rapidly narrow search to only potential solns
- Add non-technical criteria
  - Understand the maturity of the standard
  - What is the activity level of the standard
  - Where is the market going - prices/articles/etc
- Know scope of standards

Testing a Standard

- Define critical areas of both app and std
- Questions to ask
  - What to test
  - How to test
  - What happens when it doesn't work

Testing a Standard (cont)

- Testing Comm Std with COTS UUT
  - What is being tested?
  - Which is considered true?
- COTS Units don't have many test points
  - With a failure, what subsystem failed?
- If std doesn't work...
  - Relax requirement / Change the standard / Use different standard?

The NexGenBus Approach

- Research
- Bus Selection
  - 33 possible busses
    - 100 Mbps min (10 times greater than current sys)
  - 8 potential busses
    - Rate, BER, Copper/Fiber Optic, etc
  - 3 viable busses
    - Fibre Channel, Firewire, Gigabit Ethernet
  - Fibre Channel Selected for Testing

Testing

Testing

- Identify weaknesses in areas critical to instrumentation
- Using commercial standard and COTS end-items
  - Lab Tests / Analysis / Simulation / 3rd party tests
- Equipment Purchased
  - FC Protocol Analyzer, FC Traffic Generator, Communications Analyzer

Lab Testing

- Cable Analysis
  - What cables are available
  - Match their spec against NGB requirements
  - Best cables will be tested further in lab
- Connectors
  - Useable in Test Articles
  - Field manufacturable
  - EMI shielded

Simulation

- Creating initial model
  - Verifying FC against lab units
- Full model
  - Data acquisition network in Test Article
- Simulate effect of
  - Protocols
  - Topologies, Redundancy
  - Timing

The NexGenBus Approach

- Instrumentation Profile
  - Instructions on how to use the standard for instrumentation.
  - Working with the Fibre Channel Avionics Environment Working group (FC-AE)
  - Keeping the Vendor community involved to partner a solution
    - Emails
    - Web Page (http://NexGenBus.Nawcad.Navy.Mil)
    - Conferences/Symposiums